GTA Aquifer Assessment 09-11

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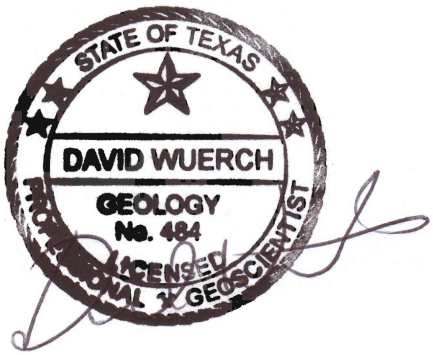

September 21, 2010

REQUESTOR:

Janet Adams, General Manager of the Jeff Davis County and Presidio County underground water conservation districts, acting on behalf of Groundwater Management Area 4.

DESCRIPTION OF REQUEST:

Ms. Janet Adams provided the Texas Water Development Board (TWDB) with draft desired future conditions for the Capitan Reef Complex, Marathon, Presidio-Redford Bolson, and Rustler aquifers in Groundwater Management Area 4 and requested that TWDB evaluate the draft desired future conditions. This aquifer analysis estimates the annual total pumping to achieve the draft desired future conditions for the Rustler Aquifer in Groundwater Management Area 4.

DRAFT DESIRED FUTURE CONDITIONS:

For the Rustler Aquifer,

- Brewster County Groundwater Conservation District (GCD)—on average a 20-foot drawdown over 50 years
- Culberson County GCD—on average a 50-foot drawdown over 50 years
- Jeff Davis County Underground Water Conservation District (UWCD)—on average a 10-foot drawdown over 50 years
- areas outside conservation district boundaries—on average a 20-foot drawdown over 50 years

METHODS:

Due to limited data on the Rustler Aquifer, a simple method of determining groundwater volume based on a uniform water-level decline was used. A transient hydrologic budget for the saturated portion of an aquifer is described by Freeze and Cherry (1979, p. 365):

$$Q(t) = R(t) - D(t) + \frac{dS}{dt}$$

where Q(t)= total rate of groundwater withdrawal
R(t)= total rate of groundwater recharge to the basin
D(t)= total rate of groundwater discharge from the basin
$\frac{dS}{dt}$ = rate of change of storage in the saturated zone of the basin

For this analysis, it is assumed that

$$R(t) = R(r) + R(e)$$

where R(r) = rejected recharge for the basin
R(e) = effective recharge

Effective recharge is the amount of water that enters an aquifer and is available for development (Muller and Price, 1979, p. 5). Rejected recharge is the amount of total (or potential) recharge that discharges from an aquifer because it is overfull and cannot accept more water (Theis, 1940, p. 1).

In addition, it is assumed that

$$R(r) \cong D(t)$$

Therefore, the total rate of groundwater pumping equals effective recharge plus the change in storage of the aquifer:

$$Q(t) = R(e) + \frac{dS}{dt}$$

All of the Rustler Aquifer within Groundwater Management Area 4 is within the Rio Grande River Basin and the Far West Regional Water Planning Area (Region E). To calculate the total pumping, the aquifer was divided into map areas by county and groundwater conservation district (Figure 1). The areal extent of each aquifer map area was calculated. These areas were used to calculate estimated annual effective recharge.

To determine the volume from storage used to reach the desired water-level drawdown, the areas were multiplied by the estimated aquifer storage coefficient and by the drained saturated thickness necessary to maintain the desired future condition. This volume was then divided by 50 years to obtain a yearly volume.

The calculations were completed in a Microsoft Excel worksheet.

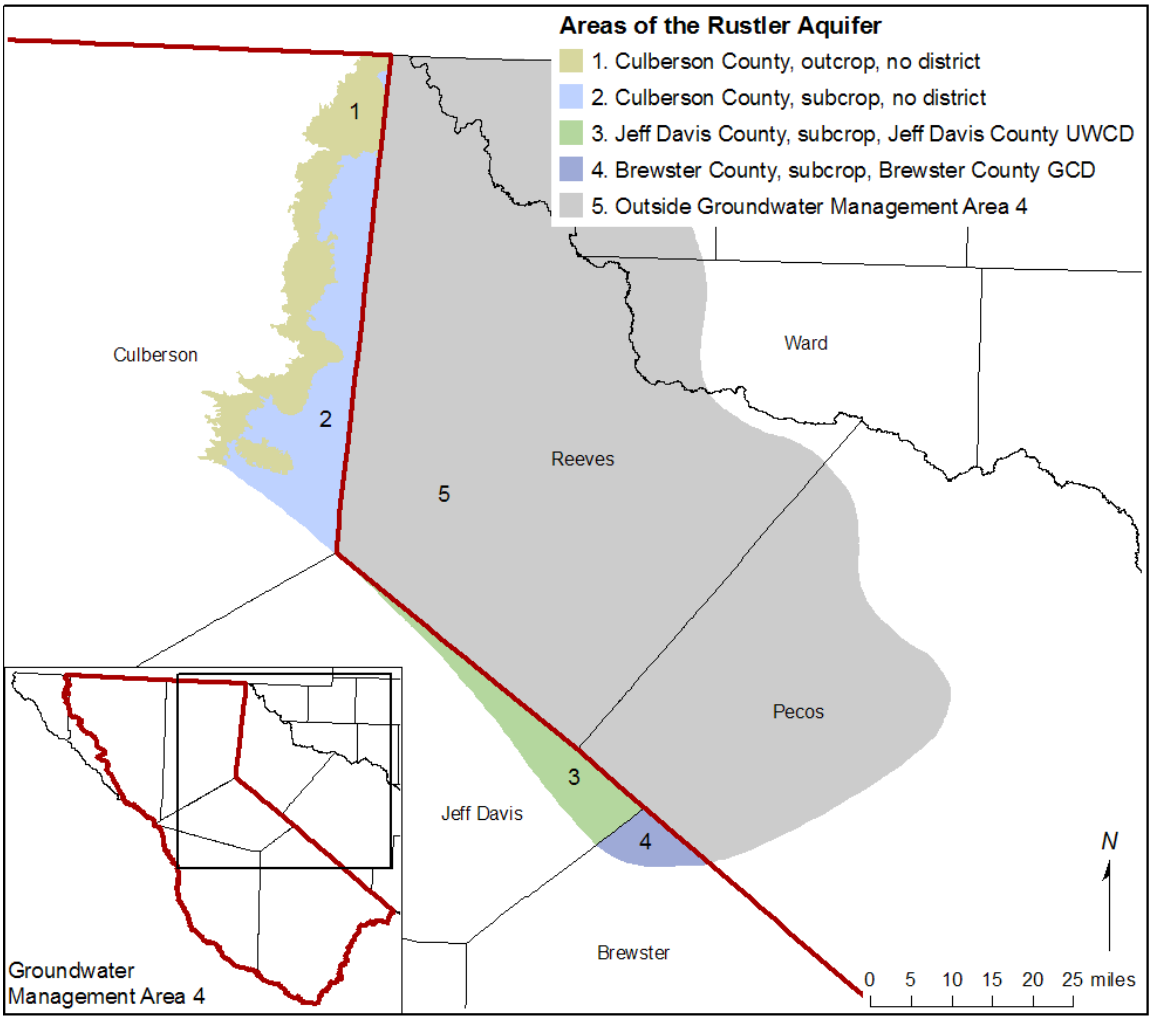

Figure 1. Map areas for estimating total pumping for the Rustler Aquifer in Groundwater Management Area 4.

PARAMETERS AND ASSUMPTIONS:

- The areas, in acres, for each map area were calculated using the TWDB shapefile for the Rustler Aquifer, projected into the groundwater availability modeling (GAM) projection (Anaya, 2001), within ArcGIS 9.3.
- Effective recharge for the Rustler Aquifer was estimated to be 1,000 acre-feet per year in Culberson County based on Muller and Price (1979). This recharge was only applied to outcrop areas.
- Estimated storage coefficients in the confined Rustler Aquifer range from 1.0×10^{-5}–1.0×10^{-4} (0.00001–0.0001), and specific yield in the unconfined portion of the aquifer is estimated to be 0.03 (LBG-Guyton

Associates, 2003). To calculate total pumping, a storage coefficient of 0.0001 and a specific yield of 0.03 were used.

- Water from the aquifer is assumed to be of usable quality. The extent of the Rustler Aquifer is defined by water with up to 5,000 mg/l total dissolved solids, higher than the limit of 3,000 mg/l total dissolved solids used for delineating most of the state's aquifers (LBG-Guyton Associates, 2003).
- The draft annual total pumping estimates are the sum of the annual effective recharge amount and the annual volume of water depleted from the aquifer based on the draft desired future condition.
- Annual volumes of water taken from storage are calculated by dividing the total volume of depletion, based on the draft desired future condition, by 50 years.
- Water-level declines are estimated to be uniform across the aquifer within map areas.
- It is assumed that the water-level declines do not exceed aquifer thickness.
- Conditions were assumed to be physically possible across the groundwater management area.

RESULTS:

The annual effective recharge estimate for the Rustler Aquifer in Groundwater Management Area 4 is 1,000 acre-feet per year, and is limited to the unconfined portion of the aquifer in Culberson County.

The results (Tables 1 and 2) show the draft annual total pumping estimates for the Rustler Aquifer in Groundwater Management Area 4. Based on the desired future conditions provided, the estimated annual total pumping volume for the Rustler Aquifer in Groundwater Management Area 4 is 3,213 acre-feet per year. Specifically,

- the area of Culberson County outside of Culberson County GCD has a total of 3,210 acre-feet per year of total pumping;
- Jeff Davis County UWCD has a total of 2 acre-feet per year of total pumping; and
- Brewster County GCD has a total of 1 acre-foot per year of total pumping.

Table 1. Estimates of draft annual total pumping for the Rustler Aquifer in Groundwater Management Area 4 summarized by map areas (see Figure 1).

GMA	Aquifer	County	GCD	Map area	Storage coefficient	Areal extent (acres)	Desired total aquifer drawdown (feet)	Estimated total volume from storage (acre-feet)	Estimated annual volume from storage (ac-ft/yr)	Estimated annual effective recharge (ac-ft/yr)	Estimated annual total volume (ac-ft/yr)
4	Rustler (unconfined)	Culberson	none	1	0.03	183,508	20	110,105	2,202	1,000	3,202
	Rustler (confined)	Culberson	none	2	0.0001	202,395	20	405	8	0	8
		Jeff Davis	Jeff Davis County UWCD	3	0.0001	101,881	10	102	2	0	2
		Brewster	Brewster County GCD	4	0.0001	34,844	20	70	1	0	1
	Rustler					Total		110,682	2,213	1,000	3,213

GMA = groundwater management area, GCD = groundwater conservation district, ac-ft/yr = acre-feet per year, UWCD = underground water conservation district.

The formulas in this table are:

storage coefficient * areal extent * desired total aquifer drawdown = estimated total volume from storage

estimated total volume from storage/50 = estimated annual volume from storage

estimated annual volume from storage + estimated annual effective recharge = estimated annual total volume

Table 2. Summary of draft annual total pumping for the Rustler Aquifer in Groundwater Management Area 4.

Map key	Aquifer	County	RWPA	River basin	GCD	GMA	GeoArea	Year	Outcrop/ subcrop	Total Pumping (ac-ft/yr)
1	Rustler	Culberson	E	Rio Grande	none	4	n/a	n/a	outcrop	3,202
2	Rustler	Culberson	E	Rio Grande	none	4	n/a	n/a	subcrop	8
3	Rustler	Jeff Davis	E	Rio Grande	Jeff Davis County UWCD	4	n/a	n/a	subcrop	2
4	Rustler	Brewster	E	Rio Grande	Brewster County GCD	4	n/a	n/a	subcrop	1

RWPA = regional water planning area, GCD = groundwater conservation district, UWCD = underground water conservation district, GMA = groundwater management area, GeoArea = geographic areas defined by unique desired future conditions as specified by a groundwater management area, ac-ft/yr = acre-feet per year.

LIMITATIONS:

Additional data are needed to create improved estimates; these estimates are a fundamental interpretation of the requested conditions. This analysis assumes homogeneous and isotropic aquifers; however, conditions for the Rustler Aquifer may not behave in a uniform manner. The analysis further assumes that lateral inflow to the aquifer is equal to lateral outflow from the aquifer and that future pumping will not alter this balance.

REFERENCES:

Anaya, R., 2001, GAM technical memo 01-01(rev a): Texas Water Development Board technical memorandum, 2 p.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, New Jersey, Prentice Hall, Inc., 604.

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Muller, D.A. and Price, R.D., 1979, Ground-water availability in Texas, estimates and projections through 2030: Texas Department of Water Resources Report 238, 77 p.

Theis, C.V., 1940, The source of water derived from wells—Essential factors controlling the response of an aquifer to development: Civil Engineering, v. 10, p. 277–280.